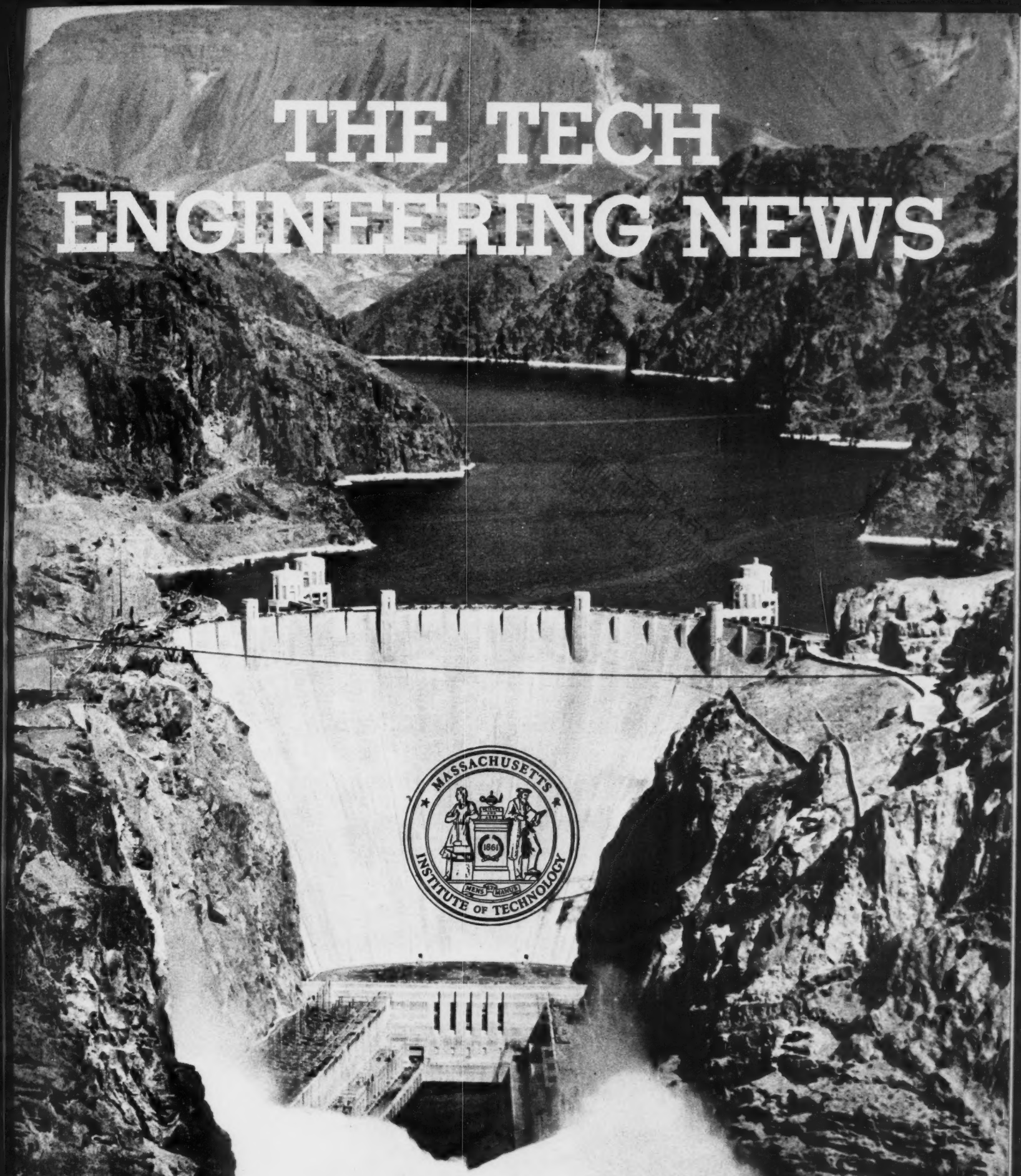
THE TECH ENGINEERING NEWS



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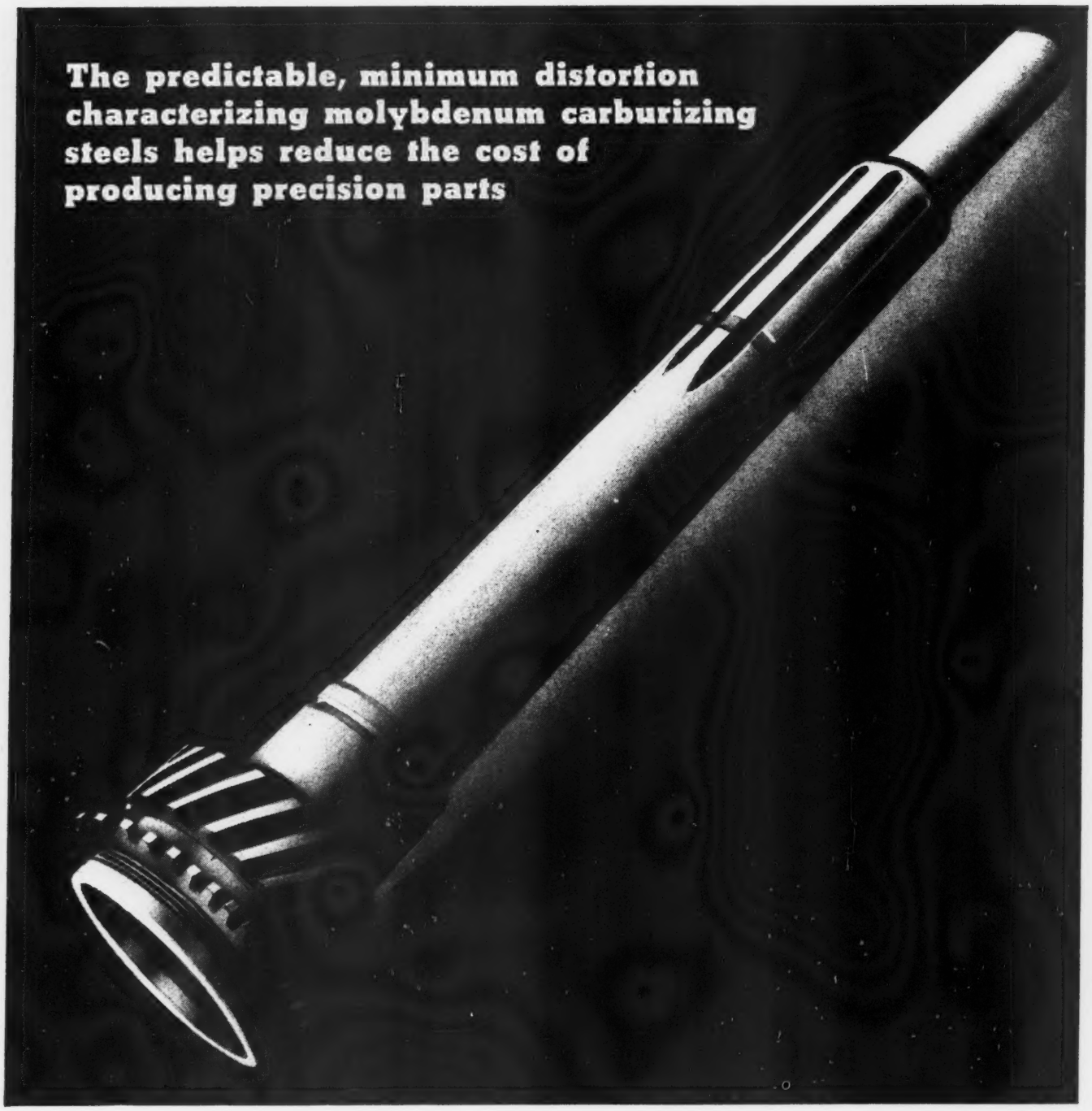

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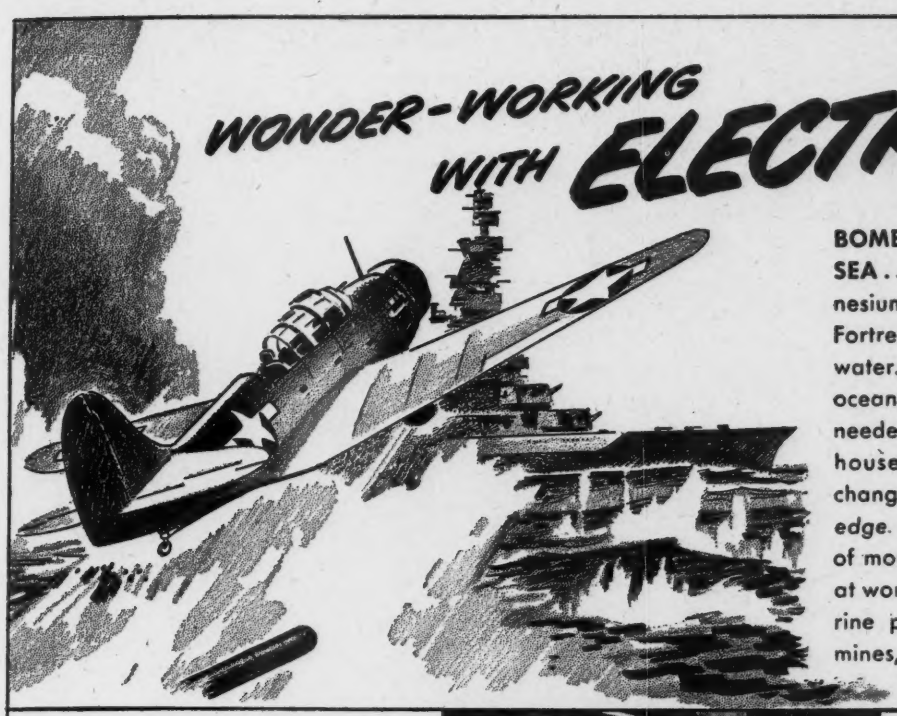

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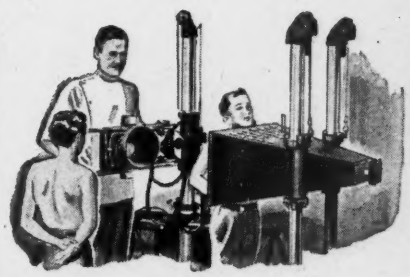

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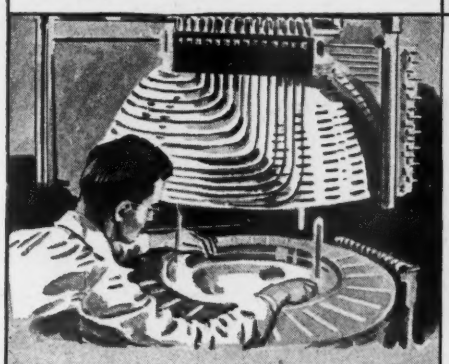

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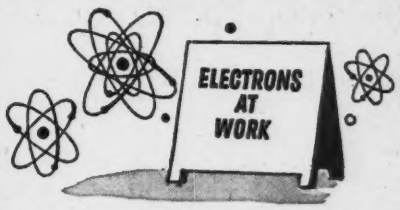

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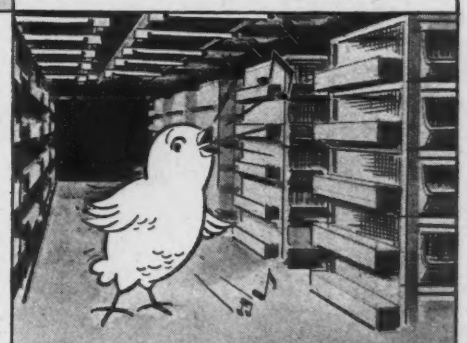

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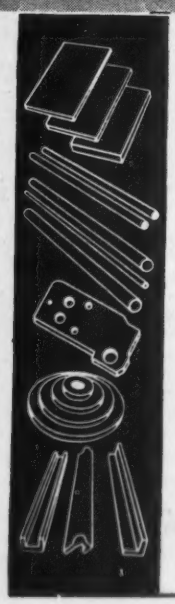

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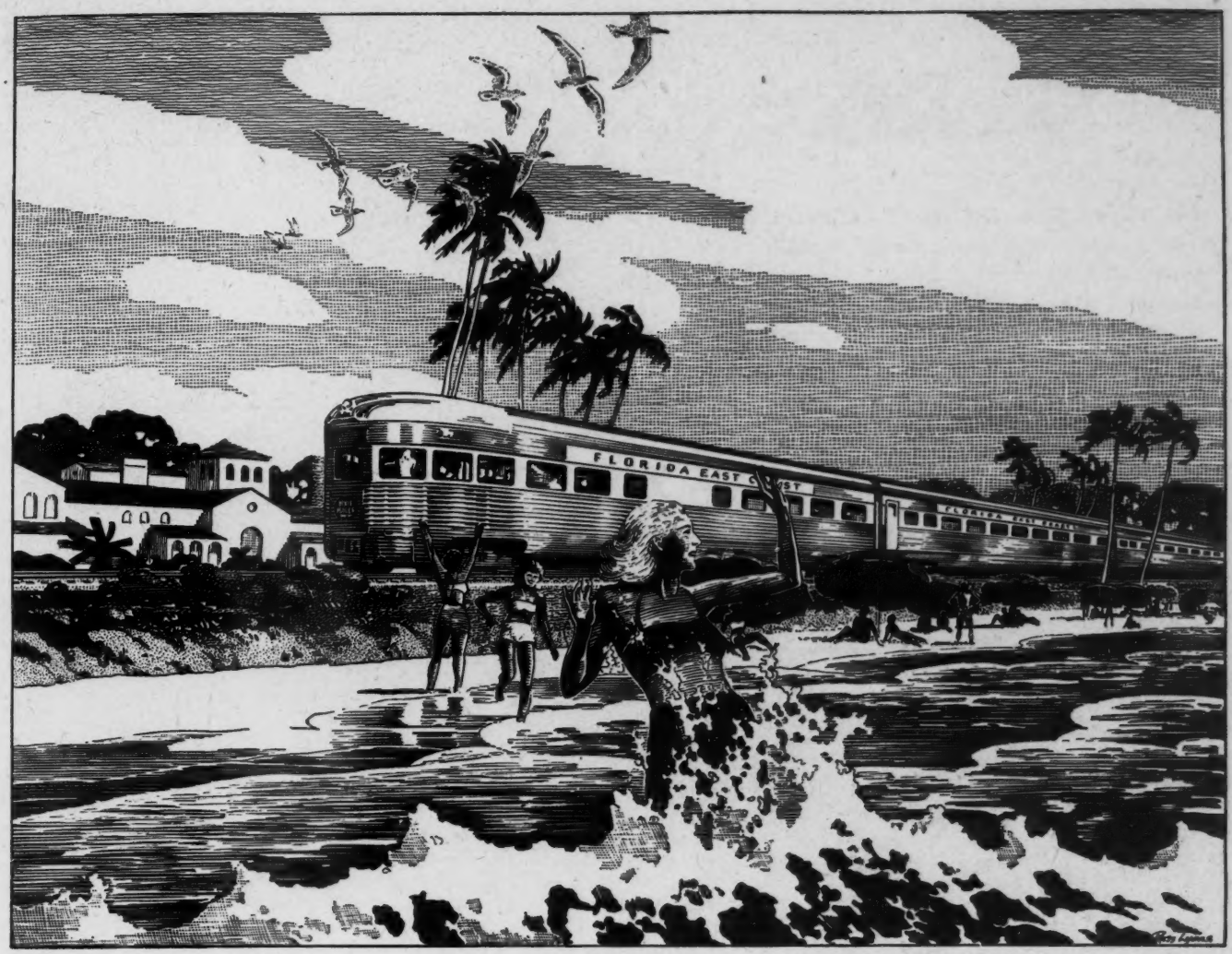

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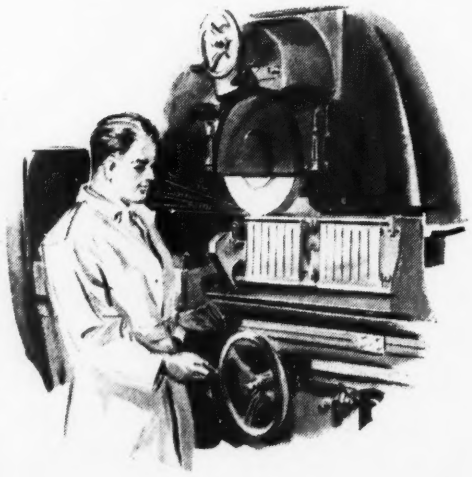

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by The Dow Chemical Company for the advancement of industry

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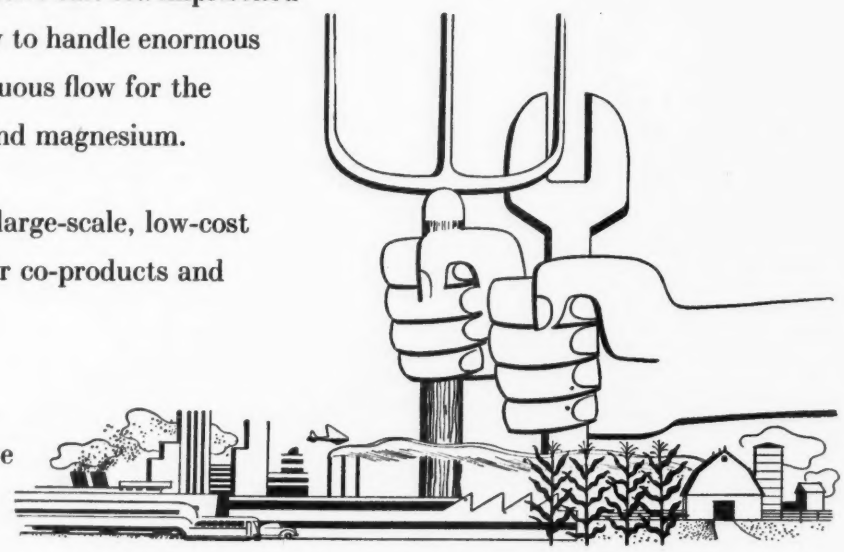

How to develop original processes for large-scale, low-cost production of these chemicals, their co-products and related materials.

How to develop plastic materials—Ethocel, Styron, Saran—with distinctive properties of varied usefulness.

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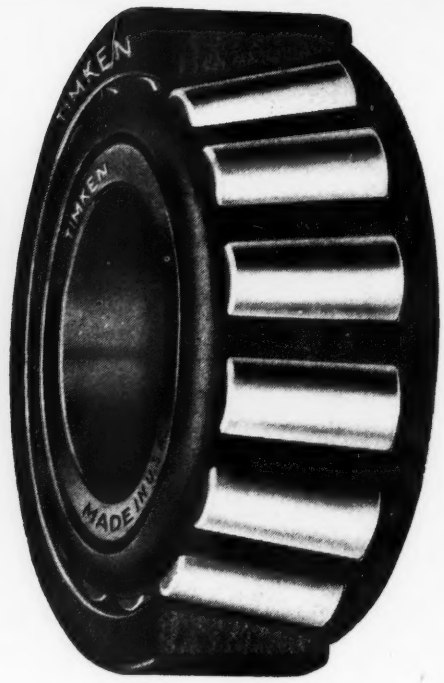

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FEBRUARY 1945

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General Electric

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Bureau of Reclamation, Department of the Interior

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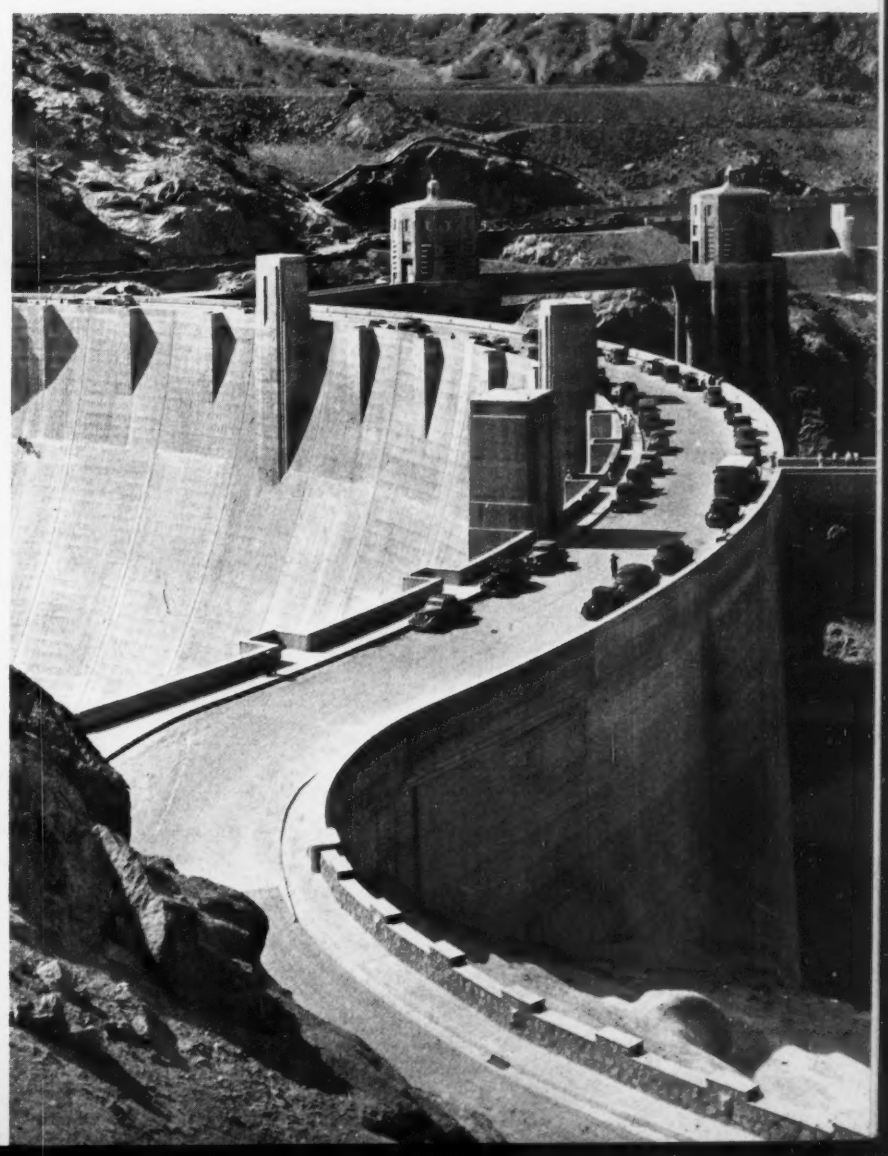


DEVELOPMENTS IN THE TENSION TEST

By C. W. MacGREGOR
Professor of Applied Mechanics, Massachusetts Institute of Technology

THE tension test is one of the most common experiments made to determine the physical properties of engineering materials. To conduct such a test when round specimens are employed, it is the usual practice to measure the axial strain over a two-inch gage length L_0 on a test bar 0.505 inches in diameter. Simultaneous readings of load P and axial deformation ΔL_0 are recorded and a $P-\Delta L_0$ diagram is constructed. When stress and strain values are plotted, these are obtained by dividing the axial load P by the original area of cross section A_0 and by dividing the ΔL_0 by the original gage length L_0 respectively. This results in a "stress-strain" curve having the same shape as the $P-\Delta L_0$ curve since it merely means that the ordinates and abscissas of this diagram are changed by a constant factor. From this conventional test, the following physical properties are usually recorded: the modulus of elasticity, the proportional limit, the yield strength, the tensile strength, and the per cents elongation and reduction of area. In each case these properties refer to the original dimensions of the test bar.

The first three of the above properties have proved to be useful for purposes of design. It is to be desired that the tension test supply more information about the material than will be disclosed by these properties alone. For example, the tension test should provide a means whereby the general effects of such conditions as heat treatment, cold work, low and elevated temperatures, chemical composition, velocity, overheating, directional properties, etc. on the strength and ductility of the material are clearly depicted. It would be desirable to correlate this with other forms of test such as the notched-beam impact, bending, torsion and general combined stress tests. Further, the tension test should provide useful information in connection with the various metal forming operations such as the rolling, drawing, and extrusion of metals. In most of these cases, the conventional form of tension test leaves much to be desired.

That the conventional form of test does not fulfill the requirements mentioned above is not surprising when one considers the empirical nature of the test. This was originally pointed out by P. Ludwik. It can be readily seen, since the area of cross section decreases greatly as the test proceeds, that a stress obtained by dividing the load at any instant by the original area does not represent a stress which is physically present. Such a stress then is fictitious and the error involved in the process becomes larger as the plastic deformation becomes greater. Near fracture, the error thus entailed may be at least one hundred per cent and in many cases even considerably larger than this.

The conventional method of defining strain as the total change in gage length divided by the original gage length is essentially a carryover from the mathematical theory of elasticity wherein the deformations are assumed to be very small. In the tension test on ductile metals the deformations become very large and the ambiguity in the choice of the reference length is emphasized by the fact that proposals have been made to define the strain as the change in gage length divided by the final length. It has been necessary to reëxamine the basic idea of strain in order to overcome this difficulty.

When the test piece starts to neck-down, the axial strain varies along the bar and at fracture the variation of the strain along the gage length becomes very great indeed. The conventional per cent elongation in two inches is then of questionable significance.

About ten years ago the writer decided to investigate this problem and an experimental program of research was undertaken at the Institute in an attempt to rationalize this form of test as far as possible. This research program has been carried out more or less continuously since then and various phases of the problem have been investigated. In the present short article it will be possible to mention only a few of the results obtained.

In order to overcome some of the difficulties and disadvantages present in the conventional form of test, the following stress and strain variables are used:

$$\text{True stress } S=\frac{P}{A} \tag{1}$$

$$\text{True strain } \epsilon=\log_e\frac{A_0}{A}=\text{True reduction of area } q' \tag{2}$$

where P, A, and A_0 are the axial load, the instantaneous area of cross section, and the original area of cross section respectively. The above relation for true strain may be derived by referring each change in dimension to the length from which that change was produced, summing up these individual small strains, and using the fundamental law of plastic flow that the volume remains constant.

The usual procedure followed in making a true

(*Continued on page 180*)

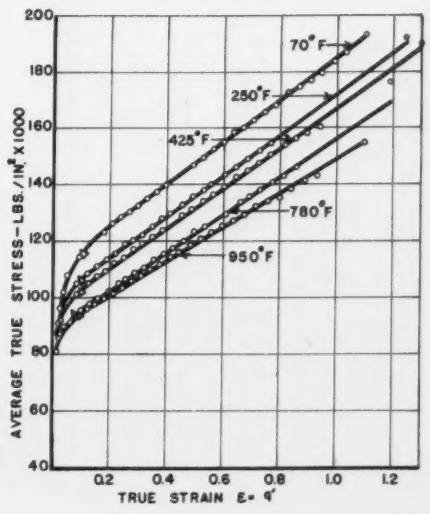


Figure 1. True stress-strain curves for chrome iron at various temperatures

FRONTISPIECE

PLYWOOD PT'S *Official U. S. Army photograph*

PLYWOOD PRODUCTION

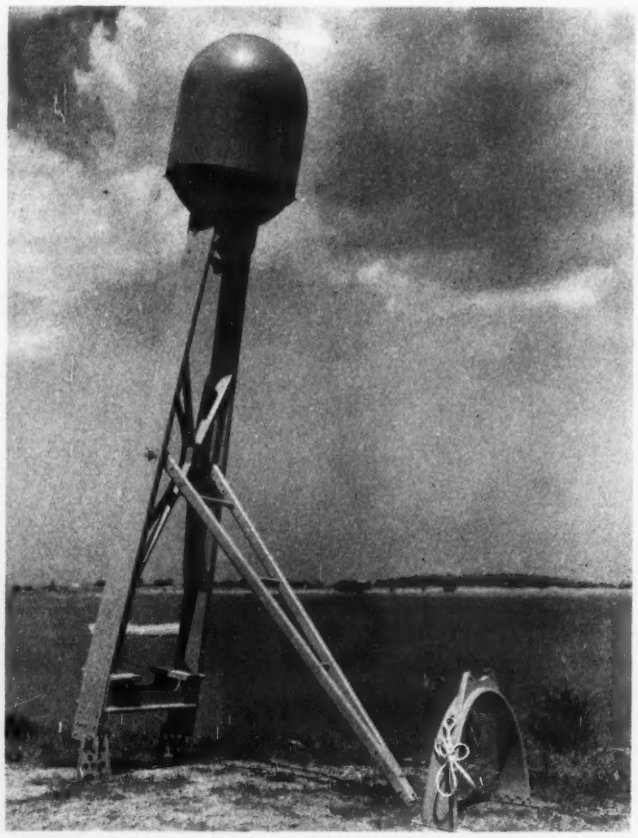
By SIDNEY L. SMITH, JR., 2-47

PLYWOOD made its first important appearance during the first World War when the sudden increase in aircraft construction demanded a structural material which could combine strength with light weight. After some use, however, it was discovered that it was unsuitable for this purpose because of the lack of durability under adverse weather conditions. Upon exposure to moisture for any length of time, the albumin and casein bonding resins used at the time exhibited a decided tendency to encourage bacterial growth or mold, and this combined with decay due to age resulted in a weakened bond. Therefore it was not surprising that during the next two decades, with their far-reaching improvements in metallurgy, the light-metal alloys of aluminum and magnesium superseded plywood in the construction of aircraft.

With the advent of the present war, however, and its attendant shortages of essential materials in aircraft production as well as in many other fields, suitable substitutes were vitally needed and had to be discovered quickly. It was then that attention was once more focused upon the possibilities of plywood, and this time it was able to withstand the strenuous tests imposed by rigid military requirements. This new increase in strength and durability was due to the development of the so-called plastic bonding using urea or phenolic resins, with their moisture resistance and absence from bacterial deterioration. Plywood is not merely a substitute, however, for it has become an important material in its own right. Aside from its widespread use in the aircraft industries, plywood has already been introduced into other fields of manufacture and is expected to find even broader applications in postwar production.

Factory methods of handling plywood are still somewhat in the experimental stage, the best progress being made in its application to aircraft production. Several important strides have been made, however, during the past two years, increasing the ease and effectiveness of the molding process and decreasing the time required for bonding and assembly gluing. Also methods have been developed which increase the strength and toughness of the wood itself.

Plywood tripod for the PT's *Hagerty Co.*



The two important plywood bonds used at present are the phenol-formaldehyde and urea-formaldehyde resin adhesives, the latter being used principally as the secondary or assembly adhesive because of the fact that its polymerization or curing does not require heat. These adhesives can be used in either a film or liquid form, or can be obtained as powders which will store excellently in the absence of water. These dry powders may be mixed with either water or alcohol or mixtures of both depending upon the concentration of solid desired in the mixture.

The primary thermo-plastic resin adhesives used in bonding must be subjected to simultaneous heat and pressure for a period varying from about five to fifteen minutes depending upon the thickness of the bond or number of veneers to be pressed. The temperature is 300° F., and the pressure varies with different densities of woods, from 125 lbs./in.^{2} on spruce to 250 lbs./in.^{2} on birch. These phenolic resins require higher heat and greater pressure for their adequate cure than is usually obtainable in assembly operations, necessitating the use of the urea resins which fortunately are well adapted for these purposes. The urea-formaldehyde adhesives will polymerize at room temperatures as low as 70° F. The application of heat up to 140° F. for a period of four to eight hours while the assembly is under pressure improves the quality of the bond and accelerates the cure.

Assembly times decrease rapidly with the increase

Langley molded plywood plane *Resinous Products and Chemical Co.*

of the temperature above 150° F. while the cure is taking place. Thus it is obvious that, with the emphasis placed upon speed by the mass production techniques of our factories, methods of introducing more heat into the glue-lines are of vital importance. At present, small assemblies are placed in "hot rooms" for curing at controlled temperature and humidity conditions, but for larger ones this is not practicable. Until recently, heat at the glue-line was dependent entirely on conduction through the veneers from hot platens on either side of the assembly, through which steam was circulated. This was a slow process at the best, however, and had several other disadvantages, the chief of which being that the heating was not uniform since the outer layers of wood were heated more quickly and to higher temperatures than those at the center. This method was especially inadequate for thicker sheets or assemblies, but is still being used for the original bonding of the normal thinner sheets.

This situation has been improved, however, by several methods of electrical heating which have been devised. The first of these involves heating the assembly by electrical resistance plates instead of the steam-heated platens and has so far proved fairly successful as small heating units can be used in assembly work. Another method, which although not yet in widespread use promises to become a practical solution to the problem of quick assembly, is the application of heat by placing the assembly in a high-frequency field. This high-frequency heating, called "cold heat," will polymerize the glue in minutes instead of hours; the heating is uniform throughout for any thickness of assembly; and there is no damage to the surface or structure of the wood by heat blisters which sometimes occur under other heating conditions. Thermal units can be attached fairly easily to cold presses for the bonding of flat plywood sheets, but this method is still difficult to apply to assembly bonding.

The most recent suggestion of means to accelerate polymerization has been to introduce the heat directly into the glue line by means of an electric current. Acetylene black is introduced into the resin mixture as a conductor, or the adhesive may be used as a film on an open-weave cloth net impregnated with the black. As yet, this method seems to be in the experimental stage only, and its possibilities still continue to be investigated.

Another one of the problems in plywood construction is the molding of the wood to the various shapes desired for different applications. Here there are two methods commonly employed — one is to bend the plywood from flat sheets by steaming them and then allowing the wood to dry in the shape desired, and the other method is to build up the veneers upon a die or mold formed in the shape desired. In this second method there is the necessity of applying uniform pressure at right angles to the curved surface as the resins are being cured; this is done best at present by fluid pressure or flexible rubber bags inflated with either air or some liquid. If circulating hot water can be used, then there is a heating effect combined with the pressure. There are many different methods of applying this flexible pressure, and several comprehensive papers have been written on that subject alone.

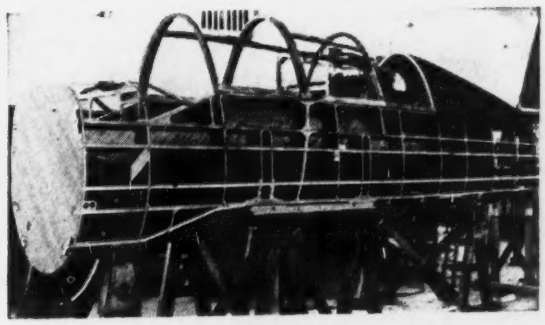
The bending of the plywood is limited by the point at which the veneers will begin to split, and placing the veneers at an angle of thirty or forty degrees to the axis of curvature will allow sharper bends to be made. Exposure to moisture and severe weather conditions will cause plywood bent from flat sheets to tend to lose its curve and return to its original condition, which may set up dangerous stresses within a structure. However, since by far the greater proportion of the moisture absorbed by plywood is absorbed through the edges of the veneers rather than the faces, this as well as many other undesirable effects of moisture on plywood may be largely prevented by taking care in the construction to leave no edges of the plywood exposed. This may be accomplished by fitting the joints with beveled strips of a hardwood such as mahogany. Where two sheets or sections of plywood must be joined together, the joint is made by beveling the edges in the opposite sense so that they fit smoothly together. This is known technically as the "scarfed joint" and allows a greater area of contact for adhesive bonding.

Plywood of higher densities, and hence increased strength, can be readily obtained since the degree of densification can be controlled by controlling the pressure, heat, and moisture content of the wood during the bonding process. Distribution of strength may be controlled by the grain direction of the various plies. Thus plywood may be adapted to a wide variety of materials, each having a combination of properties suited to a particular use. Both tensile and compressive strengths of plywood vary directly as the specific gravity of the wood, and the resin bonding is not a factor unless the content is increased so that it acts as a filler. Plywood swells upon immersion in water, and any compression which may have been supplied in the original bonding is released. Therefore these compressed high-density plywoods must not be exposed to water or high humidity conditions without an impervious coating of some sort, especially on the edges, where the water penetration is the greatest as has been noted above.

There are several processes in which the wood is actually impregnated with the thermo-plastic resins, resulting in greatly increased strength and dimensional stability. These reinforced woods go under the trade name of impreg or compreg and are particularly adapted for use as aircraft propellers. In 1944 approxi-

(*Continued on page 186*)

Vorrow trainer fuselage, showing framework and inner plywood skin *Resinous Products and Chemical Co.*



DIRECTIONAL DRILLING OF PETROLEUM WELLS

By MARVIN SWEENEY, JR., 2-47

A FEW short years ago the drilling of a crooked hole was a heinous offense; now it is an accomplishment. What has made the difference? Control! Controlled directional drilling has many applications and has become a very important petroleum industry process. Its function is simply to deflect the hole from the vertical and control its course so as to follow some predetermined path and complete it at the desired sub-surface location.

Directional drilling originated on the Pacific Coast in the Los Angeles Basin and has been used principally to tap submarine deposits of oil from land locations. It is very expensive to build piers into the ocean and then construct derricks on them to tap these deposits. Instead the derrick is built on land and the hole is deflected under the water into the oil.

More recently directional drilling has been used to return a crooked hole to a vertical course underneath the derrick and to sidetrack obstructions, such as lost tools. It may be used to relieve pressure on a burning well or one that has come in out of control; it may be used for purely exploratory purposes — spidering out from a perpendicular hole to develop sub-surface data of various types. In fact, there is no limit to the scope of controlled directional drilling.

In deep water drilling it has been used to drill as many as six wells from one foundation. When this is done the center well is straight and the rest angle off radially in the desired direction and make bottom as much as half a mile from the well. Some of these wells have been drilled as much as 72 degrees off the vertical.

The two principal tools used for directional drilling are the whipstock and the knuckle-joint. The whipstock is a wedge-shaped steel casting with a tapered or concave guide channel for the bit. It has a means of anchoring the bit in the open or cased hole so as to prevent its turning, but the anchoring device can be removed if so desired. The knuckle-joint is a universal joint provided with a bit and reamer at the lower end, held at a predetermined angle with the axis of the drill pipe, which, when set on the bottom and rotated, maintains the direction in which it was oriented.

For operation the whipstock is attached to a bit by means of a one inch diameter shear pin. After reaching the bottom of the previously drilled vertical hole the whipstock is oriented, and sufficient weight, about 20,000 pounds, is applied to force the chisel point on the lower end into the formation, thus securing it against rotation and preventing breakage of the shear pin. Bit and drill pipe are now free to rotate and move downward. Until the bit reaches the bottom of the whipstock little weight (2,000 to 3,000 pounds) is applied and rotation is slow, about 30 to 50 r.p.m. At the bottom the weight is increased to about 8,000 pounds, retaining the same speed. Since the whipstock is only used to get the deflection and start the hole it is pulled up after 10 or 15 feet of hole have been drilled. The following-up run, enlarging of the hole, and any necessary further operations, are determined by the existing conditions.

The whipstock is best adapted for hard formations and should not be used in soft formations or where heaving conditions exist, as there is danger of its sticking in the hole. The angle obtained by it is the least severe of any deflecting tool.

The knuckle-joint, upon reaching the bottom of the vertical hole, is spudded up and down to form a recess for the bit. The tool is then oriented and set by applying a weight of from 8,000 to 10,000 pounds. Once the tool is set, rotation is started at 20 to 40 r.p.m., and drilling is continued until 15 or 20 feet of hole have been drilled. The tool is then removed and the rat hole is checked. If the direction and inclination are correct, the hole is then reamed to gauge and the drilling is continued with a regular bit.

The knuckle-joint gives the most severe dog-leg as the deflection takes place in a distance equal to the length of the tool. Angles of from five to seven degrees can be obtained, varying with the formation and the method in which the tool is operated.

Experience prior to the advent of directional drilling indicates that once the drill starts to drift in a new direction, the drift is normally maintained for a considerable distance. This deflection is assumed to be due to the excessive weight on the bottom, and still more bottom weight may thus be utilized to cause still greater deflection. With such instruments as the weight

(Continued on page 186)

USES UNLIMITED

By DON DeWITT, 2-47

FROM the very beginning of the human race, waterways have been exceedingly important in everyday life. Their first and probably their most important function is transportation. From the log which was used as the first conveyance to cross a river, this mode of transportation has progressed until it has reached its present importance, and it will undoubtedly climb to even greater heights in days to come.

In the ancient days in Egypt, it was found that when the Nile overflowed its banks every year, a vast deposit of rich sediment was left upon its shores. The use of this soil turned a twenty-mile strip on the banks of the Nile into invaluable farming land.

With the development of electricity, it was found that the power created by a falling river could be converted to electrical energy. This new development opened a vast new field in the use of rivers. It was found that with the use of this power, long distance transmission could be set up, and it became economically feasible to build huge dams and hydroelectric stations across many fast flowing rivers.

For some time it was thought that this was the ultimate use of the rivers, and that these dams could only be built at places where a great deal of power was needed or could be stored. It was not until recently that other highly important uses were found for these dams which controlled the great rivers.

Some one remembered that vast northward flowing river, the Nile. Why could not any river, by the proper use of damming, favor agriculture as does the Nile? It could, and from this came many other uses: irrigation, soil conservation, drainage and flood control.

But at this point the center of interest passes from the river and the dam to the watershed which it drains. Now the dam becomes subservient to the river.

We in the United States have been the first among the nations of the world to explore the various uses of the waterways. Our first important step was the establishment of the Tennessee Valley Authority. At first this was merely to be an important power project, but it was soon found feasible to turn it into an experiment in the multiple potentialities of the river.

In 1933 the Tennessee Valley Authority started to work on a region including five states, which contained a wandering, unruly river, subject to dangerous floods, and with badly eroded soil which yielded poor returns to the farmer. The T.V.A. has since turned this area into a highly productive one, and has increased the literacy rate indirectly by helping the farmers to afford to pay taxes and support a good school system. It has built a series of dams along the river which, aside from decreasing the possibility of floods, has increased the production of power. This has been sent to the farms to make work lighter; has been sent to Muscle Shoals to help manufacture fertilizer which is sold cheaply to the farmers; and has been sent to the cities and towns to set up and build industries.

While plenty of cheap power is very important in the opening of a river to its best development, there are some other important steps which must be taken into account. Quantity and regularity of flow is very necessary. By correct farming and landscaping, it is possible to regulate the routes by which rainfall will reach a river. A river which is fed by streams is much more likely to be dirty and full of sewage than one which is spring fed. By the use of contour plowing, strip farming, and terracing, it is possible to have a maximum amount of water penetrate the surface, and build up underground reserves of water.

By keeping the flow of rivers fairly constant, the possibility of floods can be kept at a minimum, and at the same time river water will be cleaner and more healthful. There will also be a reservoir of water contained in storage wells, for the times when there is a need for it, and a great deal of soil erosion will be prevented. This will aid the farmer, the lumberman, and the average person, who depends upon these two. The fact that this method does preserve the fertility of the soil has been shown both in Tennessee, and in Delaware and Pennsylvania by the Delaware River project.

In the past fifty years amazing progress has been made in the harnessing of rivers for varied uses. New processes are still being developed both here and abroad. Some other countries where much research is being done in this field are Russia and South America. There is a great probability that in future years the uses of the rivers will be increased manyfold, and many other hidden potentialities will be uncovered.

Early dusk at Boulder Dam, and the great lanterns atop the Arizona intake towers compete with the setting sun to illumine Lake Mead. This 726-ft. dam, completed by the Bureau of Reclamation in 1935, has created an artificial lake 115 miles long and now better than two-thirds full. Its capacity is 30,500,000 acre-feet of water.

Bureau of Reclamation, Department of the Interior

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THE CIVILIZATION WE HAVE CREATED

THE TECH ENGINEERING NEWS *takes pleasure in presenting, as a special feature, the prize-winning essay submitted by one of last term's initiates to Tau Beta Pi. — Editor.*

"True science teaches, above all, to doubt and to be ignorant." — Miguel de Unamuno, "The Tragic Sense of Life."

TO us, engineers and scientists in the making, science has become more than a discipline of life; it has become a religion, the term "scientific" our watchword. Today, science has reached such a position that its true value to our society is considered self-evident. Yet it becomes apparent to the keen observer that since the first World War not everything has gone as smoothly and progressively as we have been led to believe. Especially during the present war, the ranks of the skeptics have been increased considerably. An ever increasing number of questions is being asked. Does the house that we have built ourselves fit our needs?

It is true that the blending of efforts of the scientist and the engineer together with division of labor have performed the miracle of multiplying the hour of man labor of yesterday tenfold. It is true that the farmer of today puts in only a fraction of the labor in producing a bushel of wheat that his grandfather did a century ago. But what of our modern cities and their monstrous edifices guided by the necessity of obtaining more dollars per square foot? What of our dark and narrow streets, full of claxons of automobiles, of fumes, of toxic gases, of trucks transporting alcohol, and of taxicabs transporting drunkards? What of our children whose presence in juvenile courts is ever increasing? It is evident that the effects of technology assume an unexpected character when we pause and ask "Is it true?"

It becomes apparent, then, that the magnanimous and tremendous civilization we have created somehow does not suit us. We have been guided by visions. We have not taken into account the consequences of our discoveries which have built the civilization we now question.

The illustrious Don Miguel de Unamuno, the greatest of the modern Spanish philosophers, had a particular admiration for the word "doubt." He maintained that what truths and progress had been achieved through the times was the product of this peculiar attitude. Most of us well remember our high school days. There we used to listen to the teacher say that "when two bodies are dropped from the same height in vacuum they will reach a point below at the same time, independent of the mass of the body." We accepted the statement as true. Few of us knew that for almost two thousand years men of science maintained the very opposite of what our high school teacher taught us. When Galileo disproved Aristotle's statement, men thought that they had *the* method of knowledge in their hands. The revolution was so great, the brilliant result achieved opened such shimmering panorama, the light of triumph was so intense, that the scientists could not see beyond, far away, into the soul of man where the domain of the scientific method did not reach. As always, enthusiasm exaggerated the importance of important things and overlooked deficiencies. The scientific method ushered in what the French called the Age of Reason, but it forgot that "The heart has reasons of which reason has no knowledge." Pascal was not heard, and the Age of Reason marched on.

Then came the philosophers and scientists that maintain that our evils and troubles consist in not having enough of this stuff called "scientific method." James Harvey Robinson in his "The Mind in the Making" maintains that man has not applied the scientific attitude in his thinking about himself and his social problems. But Mr. Robinson forgets that, somehow or other, the nature of man is to surround himself with poetic imagery, with symbols, with love, with hate, and to be driven by motives which originate below the neck. We may *use* the techniques of science to acquire what we want, but we shall not *want* in a scientific way.

It is evident that the civilization we have built for ourselves does not suit us. What are we to do now? Are we to take all humanity, put them in a concentration camp and shoot them full of scientific method? NO. Are we to shift the purpose of engineering and science toward a more sympathetic understanding of the complexities of life as contrasted with the simplicity of mathematical and mechanical laws? YES.

— ISAAY STEMPNITZKY.

U. S. Navy Photo

BATTLE REPORT TO ALL HANDS

EVERY seaman and officer aboard our Navy's fighting ships instantly hears the call to action, follows the battle's progress over a special type of announcing system made by Western Electric.

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Meeting the communication needs of our armed forces requires all available manpower and manufacturing facilities. That's why telephone equipment cannot now be built for civilian use. After the war, Bell Laboratories' scientists and workers at Western Electric will turn again to their peacetime jobs of designing and making telephone equipment for the Bell System.

BELL TELEPHONE SYSTEM

"Service to the Nation in Peace and War"

ALUMNUS OF THE MONTH

GEORGE R. PROUT

Electricity, Oil, Refrigeration

George R. Prout, a member of the Class of 1922, is the recently appointed Manager of the Air Conditioning and Commercial Refrigeration Divisions of General Electric's Appliance and Merchandise Department. Prior to this appointment, which took effect on July 1, 1944, Mr. Prout for three years had been Manager of the Industrial Control Division of General Electric's Apparatus Department.

Mr. Prout is a native of Quincy, Massachusetts, where he attended grade and high school. He lettered in basketball three times at Quincy High and was a member of the team that won the Massachusetts Interscholastic Basketball League Championship for the year 1916–1917. After graduating from Quincy High School in the Class of 1917, he attended Huntington School, Boston, and graduated in the Class of 1918. While at Huntington he lettered in track.

He entered M. I. T. with the Class of 1922 and completed the first two years in Course VI. At the end of his sophomore year, he entered the Coöperative Course with the General Electric Company in Electrical Engineering and worked during the summer of 1920 in the Apprentice Machine Shop at General Electric's River Works in Lynn, Massachusetts. During his remaining three years in the Coöperative Course, he worked successively on motor test, turbine test, constant current and instrument transformer tests. He also worked in the Motor Department Drafting Room, the Iron Foundry, as a moulder's helper, and on tool design. All of these assignments were in General Electric's River Works at Lynn. While on turbine test, he worked a short time on Dr. Moss' supercharger test, with little thought that this device would play such an important part in aeroplanes in World War II.

While at the Institute, he was one of the organizers and a charter member of the Honorary Society Hexalpha and one of its first officers. In coöperation with one of his classmates the first edition of *VI–A News* was published under the auspices of Hexalpha.

Mr. Prout graduated from M. I. T. in 1923 with both the Bachelor of Science and Master of Science Degrees in Electrical Engineering. At this time, having completed his test assignments with General Electric, he entered the employ of the Company in the Small Motor Department, the headquarters of which was then located at the River Works. After doing service engineering and survey work in the Company's New England District, he was transferred on September 1, 1924, to the headquarters of General Electric's Southwestern District at Dallas, Texas, as District Motor and Industrial Control Specialist. Subsequently, he was also building equipment specialist, arc welding specialist and printing machinery specialist. General Electric's Southwestern District covers the States of Texas, Oklahoma and parts of New Mexico, Arkansas and Louisiana.

In 1927 he became the District Petroleum Industry Specialist as well as Senior Motor and Industrial Control Specialist. In this capacity he worked with many oil well drilling companies, oil pipe line companies and oil producing companies on problems of this industry.

In 1929 he received the Charles A. Coffin Award for his engineering contributions in the application of electric equipment to oil pipe line pumping.

Later he became District Manager of the Industrial Department of General Electric's Southwestern District and on September 1, 1939, he was transferred to the Company's General Office at Schenectady, New York, as Sales Manager of the Industrial Control Division. In 1941 he was appointed Manager of the Industrial Control Division.

His headquarters in his new assignment as Manager of the Air Conditioning and Commercial Refrigeration Divisions is at Bloomfield, New Jersey. He is married and has two children, George, Jr., who is in the Navy V–12 program and at present is a second year medical student at Albany Medical College, Albany, New York; and a sixteen-year-old daughter, Nancy. The Prout residence at present is in Caldwell, New Jersey.

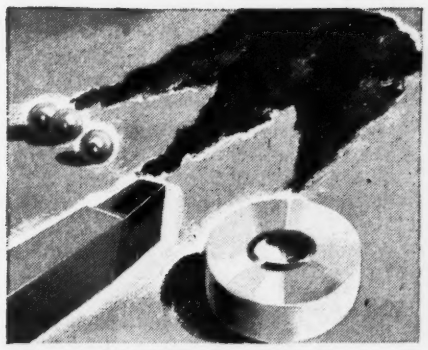
DEVELOPMENTS IN THE TENSION TEST

(*Continued from page 171*)

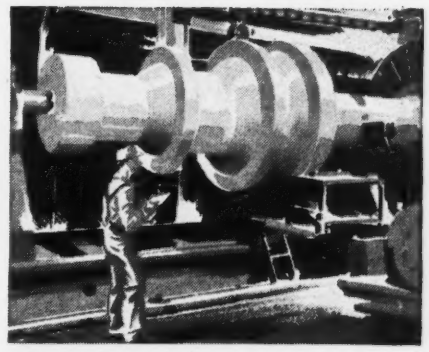
stress-true strain tension test is to take simultaneous readings of the axial load and of the minimum diameter of the test bar (if round specimens are used) from initial yielding to fracture. A stress-strain curve is then plotted using equations (1) and (2). This is called the multi-load method. It is, of course, not restricted to round bars and can be used on flat bars or specimens of other cross sections as well. The diameters are measured by means of a simple dial gage mounted in a "C" clamp having knife edges attached to the gage and to the stationary anvil of the clamp. Indeed, less equipment is needed for this form of test than for the conventional one and the time element is about the same for both. (*Continued on page 182*)

AMAZING FACTS

about the hardest metal made by man



AMAZING FACT NO. 1—Carboloy Cemented Carbide starts out as a mixture of simple metallic powders! Under heat and pressure, it is transformed into a super-hard metal—in an endless variety of shapes and forms—for machine tools, dies and wear-proofed parts.



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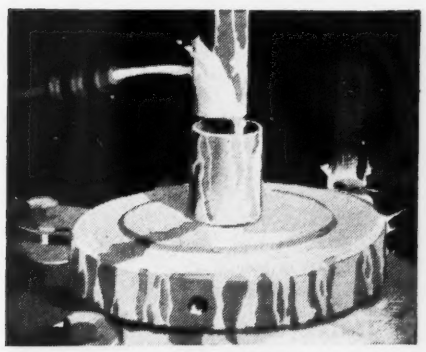

AMAZING FACT NO. 3—Carboloy Cemented Carbide has literally revolutionized production—in the forming of sheet metal, and in drawing wire and tubing, as well as in machining operations. *It has cleared* serious bottlenecks in vital war industries—speeding tank, aircraft and ammunition production, and naval building programs.

AMAZING FACT NO. 4—This miracle metal is one of the most wear-resistant materials known. This characteristic, of great value during the war, will open up countless new peacetime uses. *Examples*—valves, gauges, guides, machine parts—and non-industrial uses such as wear-resistant guides for deep sea fishing rods.

Increased output – lower costs – for you

RIGHT NOW, in *your* present shop set-up, Carboloy Cemented Carbide will step up production of vitally needed war materials.

At the same time your organization will gain valuable experience for the peacetime competitive battle to come—in which success will depend upon ability to build better products, in larger volume, at lower costs.

And remember this—in many cases Carboloy Cemented Carbide tools actually cost less than far less efficient materials for corresponding uses.

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DEVELOPMENTS IN THE TENSION TEST

(*Continued from page 180*)

For special problems, use is also made of a procedure which we have called the two-load method. In this, a properly tapered test bar is adopted and very light lines are scribed around the specimen at short intervals by means of a diamond scriber. The diameters are measured at each position before and after the test is completed. No diameter measurements are made during the test and only two loads are recorded, namely the maximum and fracture loads. These data are sufficient to construct a true stress-true strain diagram from initial yielding to fracture which will check the multi-load method in all respects. This procedure is especially useful where it is not convenient or possible to measure the diameters of the specimen during the test such as during impact or for tests at elevated temperatures.

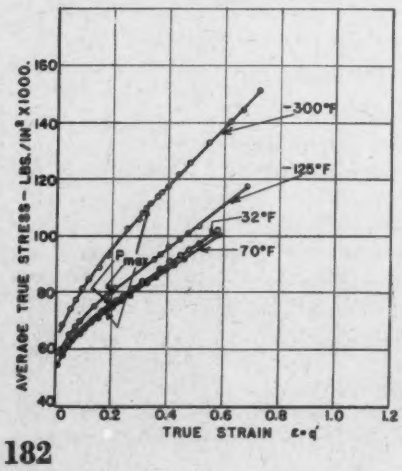

Figure 2. True stress-strain curves for brass at 70° F and below

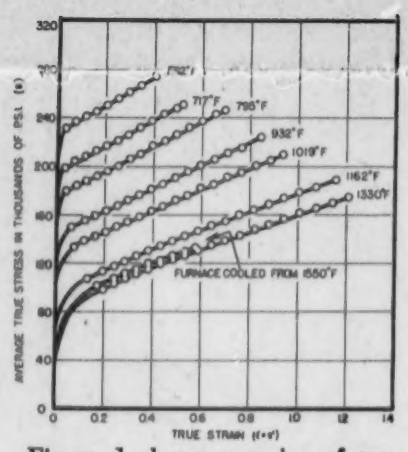

Figure 3. True stress-strain curves for SAE-1045 steel quenched from 1550° F and drawn at the temperatures indicated

Figure 1 shows a series of true stress-true strain curves for a chrome iron at various elevated temperatures. These were constructed using equations (1) and (2). It will be noted that these curves show a linear relation between stress and strain from the maximum load point, designated by triangles, to fracture. This is not an anomaly, and thousands of tests on various materials and under widely varying conditions show this linear relation. The straight line relation mentioned possesses many advantages, but these will not be discussed here.

A similar series of true stress-true strain curves for brass at temperatures varying from 70° F to −300° F is included in Figure 2. It will be noted that this material becomes stronger and more ductile as the testing temperature is decreased below room temperature.

The effect of heat-treatment of an SAE–1045 steel on the true stress-true strain curves is shown in Figure 3. In this case all specimens were quenched from 1550° F and drawn at the temperatures indicated.

The influence of testing speed on the true stress-strain relations for a brass is shown in Figure 4. The dynamic curve was obtained from Izod impact tests on round (tapered) tension specimens using the two-load method mentioned above. The maximum and fracture loads were measured by a cathode ray oscillograph. The average true strain rate for the dynamic tests was 450,000 times that for the static tests. It can be seen that the higher testing speed has increased both the strength and the ductility of this material above the static values.

It has always proved difficult in the past to find any correlation between the properties as measured in static tension tests and those as determined from notched-beam impact tests of the Charpy type on the same material. To investigate this, true stress-true strain tension tests of the static kind were made at the Institute on both uniform and notched specimens of an SAE–1045 steel which had been quenched from 1550° F and drawn at various temperatures. The notched specimens contained a "vee" notch of the same type used in the Charpy notched-beam impact test. Figure 5 shows a comparison on a specific energy basis of these static tension test results with those from Charpy notched-beam impact tests. It may be seen that when notched tension specimens are used, essentially the same information is obtained by the static tension test as is portrayed by the Charpy impact test. Aside from this agreement between the two types of tests, the static tension test yields stress-strain information not obtainable in the Charpy notched-beam impact test which measures only energy values.

In the conventional form of test, it has been customary to regard the per cent elongation ϵ_0 in two inches and the ordinary reduction of area q_0 as con-

(*Continued on page 184*)

All Napoleon needed was *one* spotter plane...

Napoleon was a hot shot artilleryman! His cannoneers had hairy ears... but better reconnaissance would have saved his bacon . . . and his empire!

One little "Spotter Plane" might have changed the face of Europe . . . and our destiny.

Every ingredient of the spotter plane that Napoleon needed was on earth then. The only reason the plane itself didn't exist was because men had not learned to "Imagineer" the things they needed.

"Imagineering" is a word we invented to describe the way Alcoa, and other great groups of technical men and women, go about the job of supplying the materials, methods and machines of modern life.

Remember this word "Imagineering". It represents the union of imagination, man's oldest mental development, and engineering, his newest. Together they are the key to progress. Together they are the engineer's contribution to mankind.

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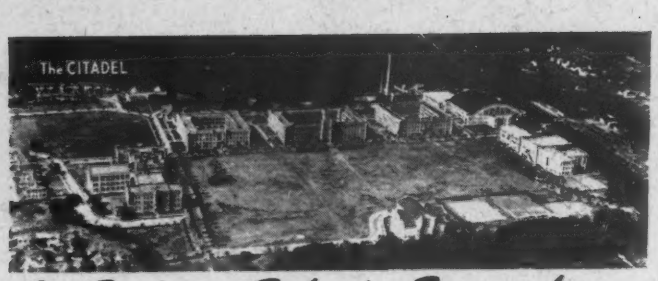

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DEVELOPMENTS IN THE TENSION TEST

(Continued from page 182)

venient measures of ductility. Some of the disadvantages in this procedure have been mentioned earlier. On the basis of experiments conducted at the Institute, two new quantities have been suggested to define ductility in the tension test. These are

$$\text{True uniform strain} \qquad \epsilon_u = \log_e \frac{A_0}{A_u} \tag{3}$$

$$\text{True local necking strain} \qquad \epsilon_n = \log_e \frac{A_u}{A_b} \tag{4}$$

where A_0, A_u and A_b are the original area of cross section, that at maximum load, and at fracture respectively. The true fracture strain represents the maximum strain which the material will withstand before fracture and is given by

$$\epsilon_b = \log_e \frac{A_0}{A_b} \tag{5}$$

It follows that

$$\epsilon_b = \epsilon_u + \epsilon_n \tag{6}$$

The relative values of the true uniform strain ϵ_u and the true local necking strain ϵ_n have considerable significance in the deep drawing of metals.

That the quantities given in equations (3) and (4) provide more information concerning the ductility characteristics of the material than do the more conventional values of ϵ_0 and q_0 can be seen by referring to Table I.

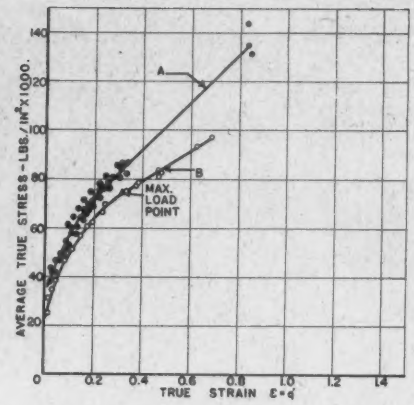


Figure 4. Comparison of true stress-strain curves for brass from static and dynamic tests using the two-load method.

Note. Curve A averages for three specimens. Average true strain rate — 190 per second
Curve B average for four specimens. Average true strain rate — 422× 10⁻⁶ per second

TABLE I

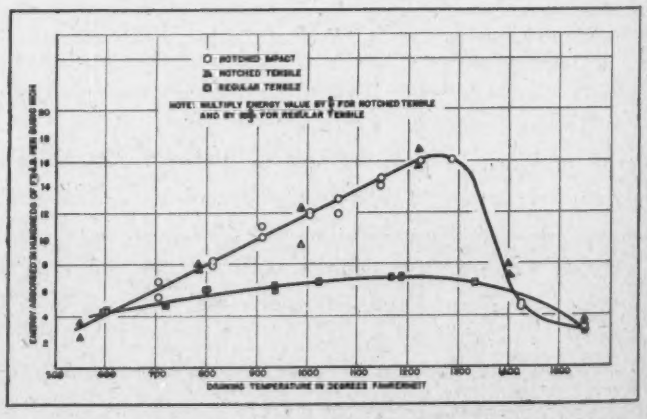
COMPARISON OF DUCTILITY VALUES

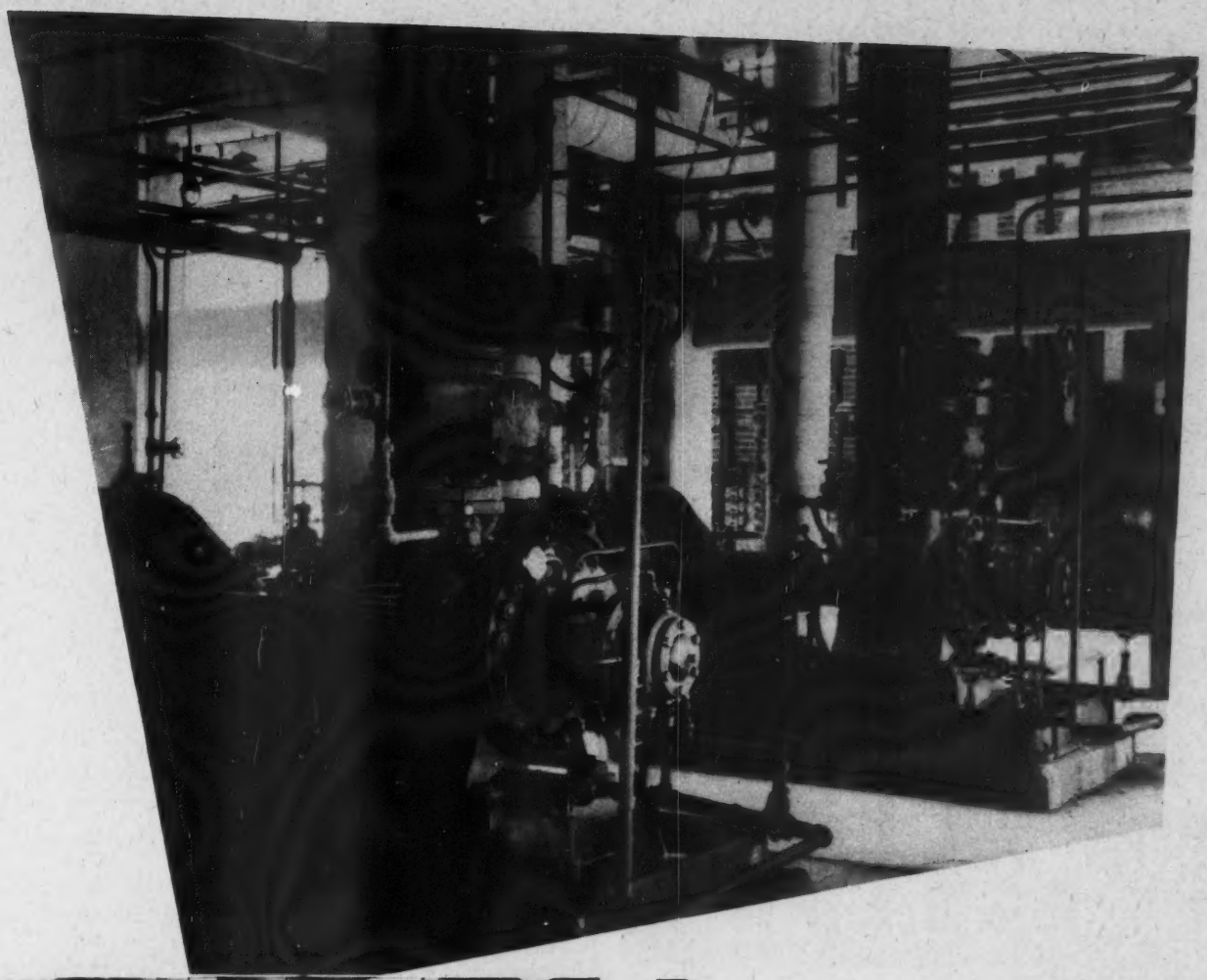
Material	ϵ_0	q_0	ϵ_u	ϵ_n
	2 in.			
Commercially Pure Copper — as received	0.149	0.605	0.0119	0.921
Cold-Drawn Brass 65–35, Annealed at 800° F for 2 hours	0.413	0.348	0.344	0.081

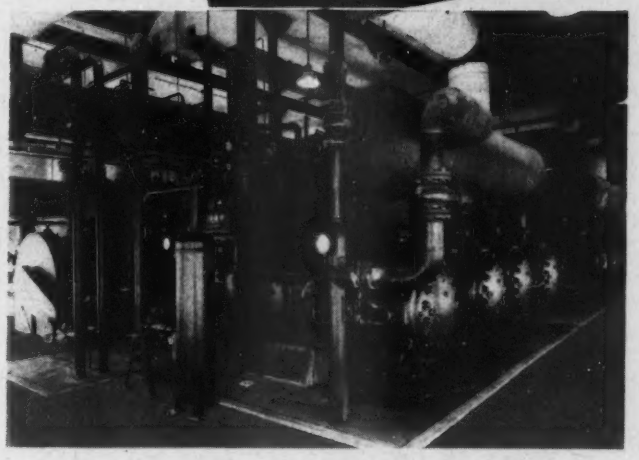
The materials listed in Table I were selected merely to serve as illustrations. Similar results were found for other metals tested. The commercially pure copper has a true local necking strain ϵ_n which is 78 times the true uniform strain ϵ_u. The brass shows that the true uniform strain ϵ_u is more than four times the local necking strain ϵ_n. It is evident that these deformation characteristics are not nearly as well portrayed by the conventional ϵ_0 and q_0 values.

Many other phases of the true stress-strain problem in relation to the tension test have been investigated. Although these cannot be reviewed here, the above examples may serve to indicate some of the desirable features of this form of tension test. Further research on this problem is under way at the present time.

Figure 5. Specific energy for fracture as determined by notched beam impact, notched tension, and uniform tension tests as a function of drawing temperature for SAE-1045 steel.







Pacifics on the job at Lake Charles

Altogether 24 Clark Compressors, totaling 15,600 B.H.P., service the Cities Service 100-Octane and Butadiene Plant at Lake Charles, Louisiana. They are grouped to function in four different processes; namely, Catalytic Cracking, Alkylation, Butadiene and De-Asphalting.

The Lake Charles Plant constitutes one of the very largest sources for 100-Octane Gas and Butadiene.

TYPE "OV" Pacific centrifugal pumps are used on the depropanizer feed at Cities Service Refining Corporation's giant 100-octane plant, Lake Charles, Louisiana.

Designed specifically for oil refinery service involving high temperatures, "OV" pumps are available in 2", 3", 4" and 6" sizes. Capacities from 100 G.P.M. to 1,500 G.P.M. Speeds up to 3,600 R.P.M. Differential pressures up to 275 pounds per stage.

Type "OV" is just one of the many Pacific Pumps designed for a specific job. See "The Refinery Catalog" for the full line of Pacific *engineered* pumps.

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BROWN & SHARPE TOOLS

DIRECTIONAL DRILLING OF PETROLEUM WELLS

(*Continued from page 176*)

indicator to control this factor with comparative accuracy, the trend at any given inclination may be sustained almost indefinitely with a uniform bottom weight, so long as other influencing factors remain unchanged. Thus, once the deflection is started, it can be maintained by a regular bit with the proper control.

It is not quite so simple, however; the penetration of formations of greater or lesser density and hardness, the speed of the drill, and many other factors affect the inclination, and it is because of these that directional drilling must be under the supervision of experienced operators. There is nothing automatic about it.

The deflection, if of any sizable angularity, is accomplished in steps. The hole is started with a deviation of a few degrees, and the drift is increased at intervals until the desired total is acquired, the hole is then straightened and this direction maintained, with adequate equipment and control, until the desired point is reached.

Beginning with the mining industries in the early eighties and the first of this century, the principles of three-dimensional well surveying have gradually been perfected and many types of instruments have been constructed for surveying the course of wells in the earth in both mineral and petroleum boring. These instruments measure and record the vertical and horizontal angles of deviation.

The vertical deviation angle is usually measured by recording the position of a plumb-bob, or the surface of a fluid in a partially filled container. The horizontal deviation angle is measured by recording the angle of a compass needle or a gyroscope wheel.

Three-dimensional well surveys are made to plot the courses of directionally drilled wells and to locate the bottoms of wells already drilled. Survey instruments are designed to make single recordings or a series of recordings at definite time intervals. Either cased or uncased holes may be surveyed and the instruments may be run in the hole on pipe, rope, or wire line. It is said that one of the postwar uses of radar will be to survey the hole constantly from the surface while drilling.

The development of controlled directional drilling has already made accessible vast reservoirs of petroleum that otherwise could not have been tapped. It has reduced costs by pointing to a more direct route to oil sands. It is fortunate that its methods and applications were known prior to the war or we would certainly be in a much more serious predicament with regard to petroleum than we are at present.

PLYWOOD PRODUCTION

(*Continued from page 173*)

mately one million pounds of compreg was manufactured for aircraft propellers alone.

As for the present applications of plywood, those in the aircraft industry are certainly the most impressive. Flat and molded plywood is being used for complete fuselages and wing structures of trainers, gliders, cargo planes, and small fighters; plywood parts and subassemblies are being used in larger transport and fighting craft. These parts include doors, seats, floors, flaps, rudders, control surfaces, propellers, spars, seaplane pontoons, and discardable gasoline tanks.

But it is not only in the air that plywood is showing its wartime uses. Wherever combined strength and lightness of weight are required plywood finds another use. In the Navy, small craft such as the famed P.T. boats are being made with complete plywood hulls, and larger vessels have plywood decks, bulkheads, housings, lifeboats, and safety rafts. There are plywood partitions and interior parts in the Liberty ships. Assault and landing craft are also made from plywood, together with the speedy storm boat, called the "waterbug," used by the Army Engineers.

Plywood used in these strenuous applications is generally faced with hard veneers of mahogany or birch, with the softer woods inside. This increases resistance to abrasion and other wear.

It is expected that after the war plywood will find extensive civilian uses, for it has been used successfully by the Army for the construction of barracks and quarters, as well as chests, lockers, cabinets, furniture, and other types of equipment. Other incidental applications are plywood ramps and pontoons for temporary bridges, plywood screens for camouflaging emplacements, and plywood domes for radar equipment in shore installations.

With more than a hundred of our factories producing plywood at full capacity, and with increasing attention being given to its production and application, the future prospects of plywood appear promising indeed.

When is FIRE *too* COLD?

FIRE was both a tool and a limitation for the ancients. With it they made things of tin and lead, silver and gold. But their fires were never hot enough for the sterner metals.

Man's progress through the ages has been accelerated each time he has learned to create and control a higher temperature.

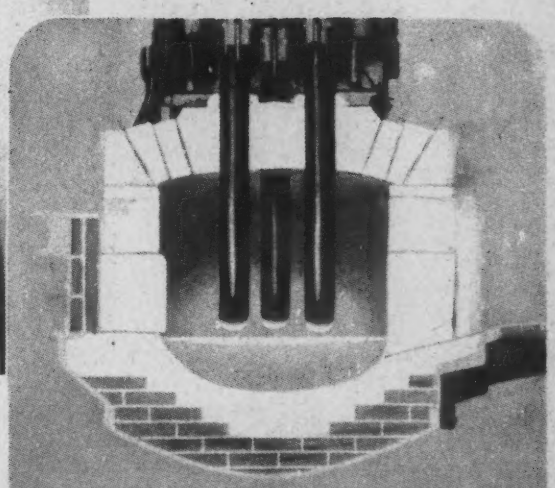
With the electric arc came heat hotter than any fire. And, by means of carbon or graphite electrodes—developed by research of NATIONAL CARBON COMPANY, INC., a Unit of UCC—man put the electric arc to work in furnaces such as the one you see above.

Born in the terrific heat of the electric furnace are many of the alloy steels used in ships, trains, planes and other equipment, and also the ferro-alloys that give strength, toughness, hardness—or the quality of being stainless—to these steels. These materials—and the intense heat that produces them—are vitally necessary to American industrial progress.

▼

Coming from the electric furnace—in addition to alloy steels and ferro-alloys—are phosphorus, abrasives, calcium carbide for acetylene used for welding and cutting, and many special alloys.

For further information write for booklet P-2, "The Story of the Carbon Arc" . . . there is no obligation.



Cross Section of an Electric Furnace

Electricity comes *to* the furnace on metal bars. It is carried *into* the furnace by carbon (or graphite) electrodes, which you see projecting down into a brick lined bowl. Carbon is used because, unlike metal, it will not melt.

You see carbon in many forms other than electrodes. Diamonds are pure carbon. Graphite, which is the "lead" in pencils, is carbon—and so are coke and charcoal. This material is the subject of unending research by the National Carbon Unit of UCC.

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Three out of four of the Navy's ships — landing craft or larger — are equipped with receivers designed by National.

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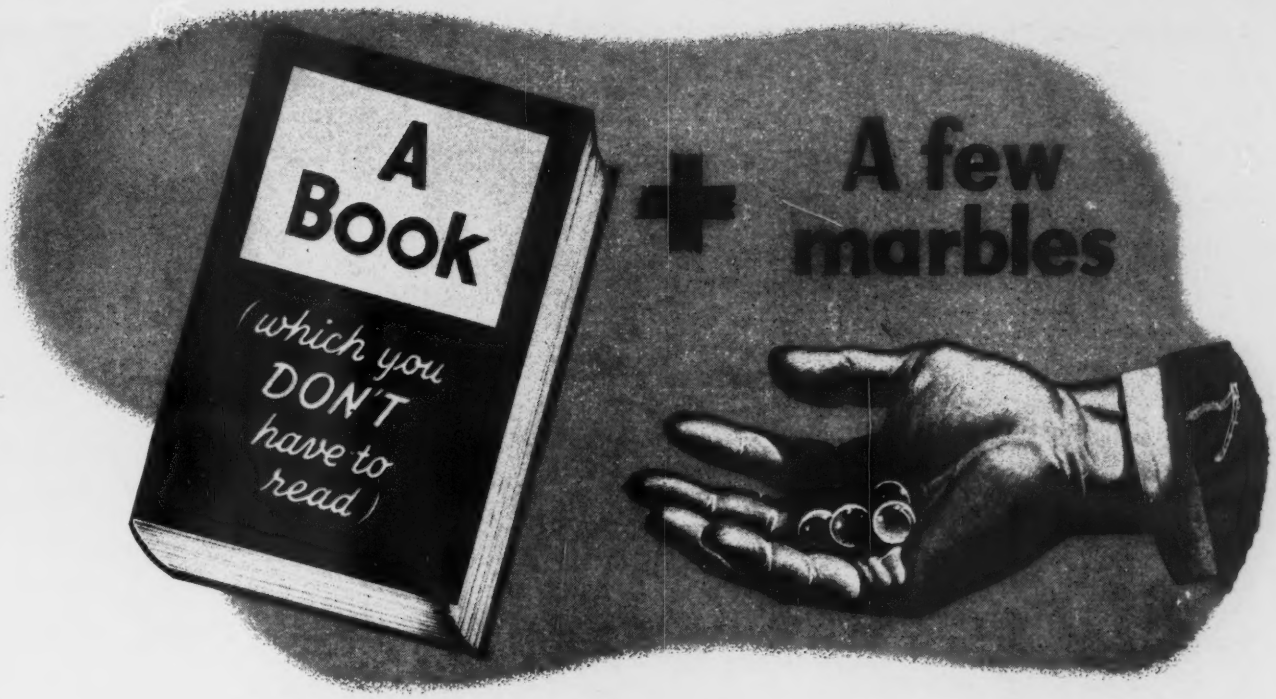
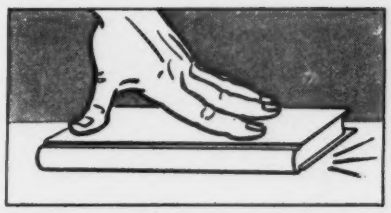
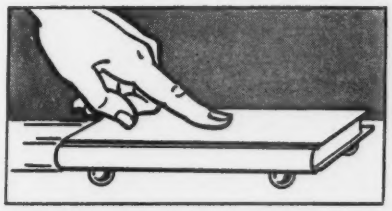


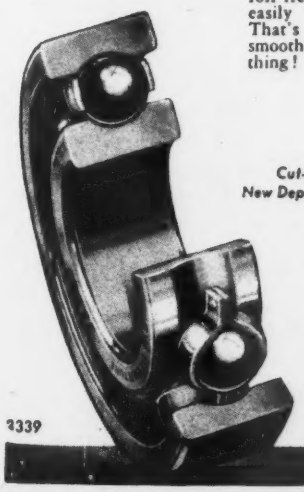
tells the WHY of Ball Bearings



TRY THIS: Place a book on your desk and your hand firmly on it. Then try to push the book across the desk. That's the principle of *sliding motion*—hard on book, desk and energy.



THEN THIS: Place 4 marbles under the book, your hand on top—and push. The marbles roll freely, the book moves easily in any direction. That's *rolling motion*—smooth and easy on everything!



Cut-away view of New Departure Ball Bearing

There is a simple, fundamental truth in the principle of the ball bearing: "Nothing Rolls Like a Ball!"

The ball possesses inherent advantages unequalled by any other rolling body. There are no *ends* to a ball—so its axis of rotation need never be artificially fixed.

Thus, a *Ball* bearing bears the loads on a circle of *free rolling* steel balls, reducing friction and wear, maintaining precise location of parts and cutting maintenance time—as does no other type bearing.

That is why over 300 million New Departure Ball Bearings are at work in this war. *That* is why designers of peace-time machinery are designing more ball bearings into their machinery than ever before.

There is really no substitute for the ball bearing—nor any substitute for the technical experience and creative engineering that go into New Departure Ball Bearings.

Ask for your free copy of "Why Anti-friction Bearings?"

nothing rolls like a ball

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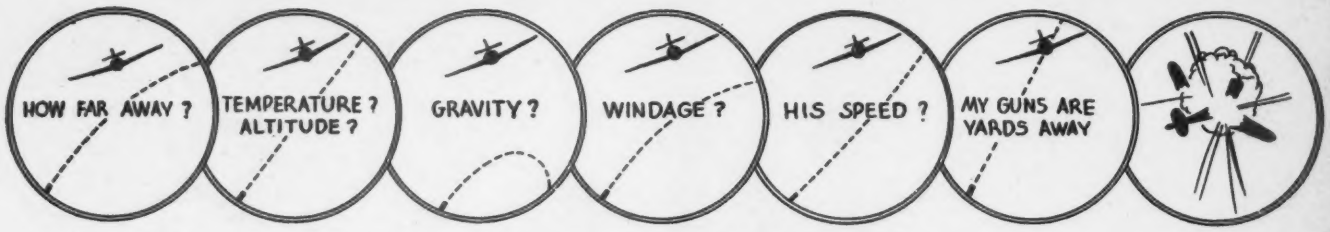
G-E Campus News

RESEARCH AND ENGINEERING KEEP GENERAL ELECTRIC YEARS AHEAD



HEAVY HEADWORK

THE Boeing B-29 Superfortress has an "electric brain." And it's pretty comforting and assuring for a gunner to toss some of the heavy headwork over to it when a Jap Zero is pumping shells at him and flying as fast as he is, or faster.

The "brain," or computer, is continuously solving an equation and making a continuous adjustment of his gun's aim. There are many elements in that equation—temperature, plane speed, windage, for example. And his bullet is fired, not at the enemy plane, but at where it's going to be a fraction of a second later. The computer supplements and corrects human judgment in the factors conditioning that aim, takes over that part of the gunner's responsibility.

The "brain" has electronic tubes—plus other electrical and mechanical elements—to help with its important thinking. The corrections are relayed to the guns continuously and automatically. And the gunner is free to concentrate on the business of keeping the Jap plane framed in his sights.

BOUNCING PUTTY

BOUNCE it like a ball—pull it like taffy. "Bouncing putty" is the most entertaining member of the silicone family. It's a by-product of the research that's kept G-E chemists busy for a number of years.

As a result of their work, silicon, an element found in sand and glass, has become the backbone of a whole new group of compounds. One of them is a rubber that stands temperatures from 575 F all the way down to 60 below. Groups of atoms—silicon and oxygen—arranged in a repetitive manner, make up its polymeric molecules.

Silicone rubber can be used for a lot of things, such as gaskets in turbosuperchargers and searchlights. It's unique, because it returns to its original height and shape even after compression under extreme heat.

MOIDER DA BUMS

DOWN in New Guinea tonight they're burning 'em over the plate . . . and heaving coke bottles at the umpire.

Antiaircraft battalions made night baseball possible, first by bulldozing a piece of jungle clear and level. Then the boys made 12 coconut trees into poles, installed them around the field, and nailed 20-foot-square white board reflectors to the tops of them. They anchored 800-million candlepower searchlights at the base of each pole, and focused their beams on the white boards.

General Electric salutes its fellow lighting engineers who found a way to bring Brooklyn to the New Guinea jungle. *General Electric Co., Schenectady 5, N.Y.*

Hear the G-E radio programs: "The G-E All-girl Orchestra" Sunday 10 p.m. EWT, NBC—"The World Today" news, Monday through Friday, 6:45 p.m. EWT, CBS—The G-E House Party, Monday through Friday, 4:00 p.m. EWT, CBS.

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